

**CLAIMS:**

1. A semiconductor doped with an increased binding energy hydrogen compound.
2. A doped semiconductor according to claim 1, wherein said semiconductor has an altered band gap relative to the semiconductor material which is undoped.
3. A doped semiconductor according to claim 1, wherein said semiconductor has an altered band gap relative to the semiconductor material which is doped with a dopant other than said increased binding energy hydrogen compound.
4. A doped semiconductor according to claim 1, wherein the semiconductor material comprises at least one selected from the group consisting of silicon, boron, aluminum, Group III elements, Group IV elements and Group V elements.
5. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen compound comprises an increased binding energy hydride ion.
6. A doped semiconductor according to claim 1, wherein said doped semiconductor has been doped with said increased binding energy hydrogen compound by ion implantation, epitaxy or vacuum deposition.
7. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprises a hydrino atom having a (desired energy level).
8. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprises at least one neutral, positive or negative increased binding energy hydrogen species having a binding energy:
  - (i) greater than the binding energy of the corresponding ordinary hydrogen species, or
  - (ii) greater than the binding energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energy of the ordinary hydrogen species at ambient conditions, or is negative.
9. A doped semiconductor according to claim 8, wherein said increased binding energy hydrogen species is selected from the group consisting of  $H_n$ ,  $H_n^-$ , and  $H_n^+$ , where  $n$  is an integer of 1 to 8, and  $n$  is greater than 1 when  $H$  has a positive charge.
10. A doped semiconductor according to claim 8, wherein said increased binding energy hydrogen species comprises at least one other element selected from the group consisting of a proton, ordinary hydride ion, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions and ordinary

H<sub>3</sub><sup>+</sup>.

11. A doped semiconductor according to claim 8, wherein said increased binding energy hydrogen species comprises at least one other element selected from the group consisting of alkaline earth metals and alkali metals.
12. A doped semiconductor according to claim 8, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of organic compounds.
13. A doped semiconductor according to claim 8, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of semiconductors.
14. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for  $p = 2$  up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where  $p$  is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and  $e$  is the elementary charge; (b) hydrogen atom having a binding energy greater than about 13.6 eV; (c) hydrogen molecule having a first binding energy greater than about 15.5 eV; and (d) molecular hydrogen ion having a binding energy greater than about 16.4 eV.

15. A doped semiconductor according to claim 1, wherein the increased binding energy species is hydride ion having a binding energy of about 3.0, 6.6, 11.2, 16.7, 22.8, 29.3, 36.1, 42.8, 49.4, 55.5, 61.0, 65.6, 69.2, 71.53, 72.4, 71.54, 68.8, 64.0, 56.8, 47.1, 34.6, or 19.2.
16. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species is a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for  $p = 2$  up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where  $p$  is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and  $e$  is the elementary charge.

17. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydrino atom having a binding energy of about  $13.6 \text{ eV}/(1/p)^2$ , where  $p$  is an integer greater than 1; (b) a hydride ion having a binding energy represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where  $p$  is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and  $e$  is the elementary charge; (c) a trihydrino molecular ion,  $\text{H}_3^+$  ( $1/p$ ), having a binding energy of about  $22.6/(1/p)^2 \text{ eV}$ ; (d) an increased binding energy hydrogen molecule having a binding energy of about  $15.5/(1/p)^2 \text{ eV}$ ; and (e) an increased binding energy hydrogen molecular ion with a binding energy of about  $16.4/(1/p)^2 \text{ eV}$ .

18. A doped semiconductor according to claim 17, wherein  $p$  is 2 to 200.
19. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species has a negative charge.
20. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species further comprises at least one cation.
21. A doped semiconductor according to claim 20, wherein said cation is a proton,  $\text{H}_2^+$  or  $\text{H}_3^+$ .
22. A doped semiconductor according to claim 1, wherein said at least one

increased binding energy hydrogen species having an observed characteristic different from that of the corresponding ordinary compound wherein the hydrogen content is only ordinary hydrogen, said observed characteristic being dependent on the increased binding energy hydrogen species.

23. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydride ion having a binding energy greater than 0.8 eV.
24. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen atom having a binding energy of about  $13.6/n^2$  eV, wherein  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.
25. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen molecule having a first binding energy of about  $15.5/n^2$  eV, wherein  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.
26. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy molecular hydrogen ion having a first binding energy of about  $16.4/n^2$  eV, wherein  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.
27. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one hydride ion having a binding energy of about 0.65 eV.
28. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising at least one hydride ion formulated from at least one hydrino atom.
29. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species comprising  $H_3^+$  increased binding energy hydrogen species.
30. A doped semiconductor according to claim 1, wherein said increased binding energy hydrogen species further comprises at least one other element.
31. A doped semiconductor according to claim 30, wherein said at least one other element comprises at least one selected from the group consisting of ions and compounds containing an increased binding energy species.
32. A doped semiconductor according to claim 30, wherein said at least one other

element comprises one or more normal hydrogen atoms.

33. A doped semiconductor according to claim 30, wherein said at least one other element comprises at least one selected from the group consisting of a proton, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions, ordinary hydride ions, and ordinary  $H_3^+$ .
34. A doped semiconductor according to claim 30, wherein said at least one other element comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.
35. A doped semiconductor according to claim 30, wherein said at least one other element comprises at least one element selected from the group consisting of organic compounds.
36. A doped semiconductor according to claim 30, wherein said at least one other element comprises at least one element selected from the group consisting of semiconductors.
37. A doped semiconductor according to claim 30, wherein said at least one other element comprises a refractory metal.
38. A doped semiconductor according to claim 30, wherein said at least one other element comprises a metal.
39. A doped semiconductor according to claim 30, wherein said at least one other element comprises an electrical conductor.
40. A doped semiconductor according to claim 30, wherein said at least one other element comprises a source of thermal electrons.
41. A doped semiconductor according to claim 30, wherein said semiconductor is doped with a dopant comprising said increased binding energy hydrogen species.
42. A doped semiconductor according to claim 41, wherein the dopant has the formula selected from the group of formulae consisting of  $MH$ ,  $MH_2$ , and  $M_2H_2$  wherein  $M$  is an alkali cation and  $H$  is selected from the group consisting of increased binding energy hydride ions, hydrino atoms and dihydrino molecules.
43. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MH_n$  wherein  $n$  is 1 or 2,  $M$  is an alkaline earth cation and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

44. A doped semiconductor according to claim 41, wherein the dopant has the formula MHX wherein M is an alkali cation, X is one of a neutral atom, a molecule, or a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
45. A doped semiconductor according to claim 44, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
46. A doped semiconductor according to claim 41, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
47. A doped semiconductor according to claim 46, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
48. A doped semiconductor according to claim 41, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a doubly negatively charged anion, and H is a hydrino atom.
49. A doped semiconductor according to claim 41, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
50. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2HX$  wherein M is an alkali cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
51. A doped semiconductor according to claim 50, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
52. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MH_n$  wherein n is an integer from 1 to 5, M is an alkali cation and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
53. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2H_n$  wherein n is an integer from 1 to 4, M is an alkaline earth cation and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.

54. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2XH_n$  wherein  $n$  is an integer from 1 to 3,  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
55. A doped semiconductor according to claim 54, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
56. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2X_2H_n$  wherein  $n$  is 1 or 2,  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
57. A doped semiconductor according to claim 56, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
58. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2X_3H$  wherein  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
59. A doped semiconductor according to claim 58, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
60. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2XH_n$  wherein  $n$  is 1 or 2,  $M$  is an alkaline earth cation,  $X$  is a doubly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
61. A doped semiconductor according to claim 60, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
62. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2XX'H$  wherein  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion,  $X'$  is a doubly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
63. A doped semiconductor according to claim 62, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

64. A doped semiconductor according to claim 62, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
65. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MM'H_n$  wherein  $n$  is an integer from 1 to 3,  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
66. A doped semiconductor according to claim 41, wherein the dopant is  $MM'XH_n$  wherein  $n$  is 1 to 2,  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation,  $X$  is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
67. A doped semiconductor according to claim 66, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
68. A doped semiconductor according to claim 41, wherein the dopant is  $MM'XH$  where  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation,  $X$  is a doubly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
69. A doped semiconductor according to claim 68, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
70. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MM'XX'H$  where  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation,  $X$  and  $X'$  are each a singly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
71. A doped semiconductor according to claim 70, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
72. A doped semiconductor according to claim 41, wherein the dopant has the formula  $H_nS$  wherein  $n$  is 1 or 2, and the hydrogen content of  $H_n$  comprises at least one increased binding energy hydrogen species.
73. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MSiH_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content of  $H_n$  comprises at least one increased binding



energy hydrogen species.

74. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MXM'H_n$  wherein
  - n is an integer from 1 to 5;
  - M is an alkali or alkaline earth cation;
  - X is a singly negatively charged anion or a doubly negatively charged anion;
  - M' is selected from the group consisting of Si, Al, Ni, the transition elements, the inner transition elements, and the rare earth elements; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
75. A doped semiconductor according to claim 74, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
76. A doped semiconductor according to claim 74, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
77. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MAIH_n$  wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
78. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MH_n$  wherein:
  - n is an integer from 1 to 6;
  - M is selected from the group consisting of the transition elements, the inner transition elements, and the rare earth element cations and nickel; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
79. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MNiH_n$  wherein:
  - n is an integer from 1 to 6;
  - M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
80. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MM'H_n$  wherein:
  - n is an integer from 1 to 6;

M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum;

M' is selected from the group consisting of the transition elements, the inner transition elements, and rare earth element cations; and

the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.

81. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2SiH_n$  wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
82. A doped semiconductor according to claim 41, wherein the dopant has the formula  $Si_2H_n$  wherein n is an integer from 1 to 8, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
83. A doped semiconductor according to claim 41, wherein the dopant has the formula  $SiH_n$  wherein n is an integer from 1 to 8, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
84. A doped semiconductor according to claim 41, wherein the dopant has the formula  $TiH_n$  wherein n is an integer from 1 to 4, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
85. A doped semiconductor according to claim 41, wherein the dopant has the formula  $Al_2H_n$  wherein n is an integer from 1 to 4 and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
86. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MXAIX'H_n$  wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
87. A doped semiconductor according to claim 86, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
88. A doped semiconductor according to claim 86, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
89. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MXSiX'H_n$  wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively

charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.

90. A doped semiconductor according to claim 89, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
91. A doped semiconductor according to claim 89, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
92. A doped semiconductor according to claim 41, wherein the dopant has the formula  $SiO_2H_n$  wherein  $n$  is an integer from 1 to 6 and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
93. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MSiO_2H_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
94. A doped semiconductor according to claim 41, wherein the dopant has the formula  $MSi_2H_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
95. A doped semiconductor according to claim 41, wherein the dopant has the formula  $M_2SiH_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
96. A doped semiconductor according to claim 41, wherein said dopant having a formula  $[KH_mKCO_3]_n$  wherein  $m$  and  $n$  are each an integer and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
97. A doped semiconductor according to claim 41, wherein said dopant having a formula  $[KH_mKNO_3]_n^+ nX^-$  wherein  $m$  and  $n$  are each an integer,  $X$  is a singly negatively charged anion, and the hydrogen content of  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
98. A doped semiconductor according to claim 97, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
99. A doped semiconductor according to claim 41, wherein said dopant having a

formula  $[KHKNO_3]_n$  wherein  $n$  is an integer and the hydrogen content  $H$  of the dopant comprises at least one said binding energy hydrogen species.

100. A doped semiconductor according to claim 41, wherein said dopant having a formula  $[KHKOH]_n$  wherein  $n$  is an integer and the hydrogen content  $H$  of the dopant comprises at least one said binding energy hydrogen species.
101. A doped semiconductor according to claim 41, wherein said dopant having a formula  $[MH_mM'X]_n$  wherein  $m$  and  $n$  are each an integer,  $M$  and  $M'$  are each an alkali or alkaline earth cation,  $X$  is a singly or doubly negatively charged anion, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
102. A doped semiconductor according to claim 101, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
103. A doped semiconductor according to claim 101, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
104. A doped semiconductor according to claim 41, wherein said dopant having a formula  $[MH_mM'X]^+_n nX^-$  wherein  $m$  and  $n$  are each an integer,  $M$  and  $M'$  are each an alkali or alkaline earth cation,  $X$  and  $X^-$  are a singly or doubly negatively charged anion, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
105. A doped semiconductor according to claim 104, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
106. A doped semiconductor according to claim 104, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
107. A doped semiconductor according to claim 41, wherein said dopant having a formula  $MXSiX'H_n$  wherein  $n$  is 1 or 2,  $M$  is an alkali or alkaline earth cation,  $X$  and  $X'$  are with a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
108. A doped semiconductor according to claim 107, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.

109. A doped semiconductor according to claim 107, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
110. A doped semiconductor according to claim 41, wherein said dopant having a formula  $MSiH_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
111. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_{4n}$  wherein  $n$  is an integer and the hydrogen content  $H_{4n}$  of the dopant comprises at least one increased binding energy hydrogen species.
112. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_{3n}$  wherein  $n$  is an integer and the hydrogen content  $H_{3n}$  of the dopant comprises at least one increased binding energy hydrogen species.
113. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_{3n}O_m$  wherein  $n$  and  $m$  are integers and the hydrogen content  $H_{3n}$  of the dopant comprises at least one increased binding energy hydrogen species.
114. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_xH_{4x-2y}O_y$  wherein  $x$  and  $y$  are each an integer and the hydrogen content  $H_{4x-2y}$  of the dopant comprises at least one increased binding energy hydrogen species.
115. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_xH_{4x}O_y$  wherein  $x$  and  $y$  are each an integer and the hydrogen content  $H_{4x}$  of the dopant comprises at least one increased binding energy hydrogen species.
116. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_{4n}H_2O$  wherein  $n$  is an integer and the hydrogen content  $H_{4n}$  of the dopant comprises at least one increased binding energy hydrogen species.
117. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_{2n+2}$  wherein  $n$  is an integer and the hydrogen content  $H_{2n+2}$  of the dopant comprises at least one increased binding energy hydrogen species.
118. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_xH_{2x+2}O_y$  wherein  $x$  and  $y$  are each an integer and the hydrogen content  $H_{2x+2}$  of the dopant comprises at least one increased binding energy hydrogen species.
119. A doped semiconductor according to claim 41, wherein said dopant having a

formula  $Si_nH_{4n-2}O$  wherein  $n$  is an integer and the hydrogen content  $H_{4n-2}$  of the dopant comprises at least one increased binding energy hydrogen species.

120. A doped semiconductor according to claim 41, wherein said dopant having a formula  $MSi_{4n}H_{10n}O_n$  wherein  $n$  is an integer,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_{10n}$  of the dopant comprises at least one increased binding energy hydrogen species.
121. A doped semiconductor according to claim 41, wherein said dopant having a formula  $MSi_{4n}H_{10n}O_{n+1}$  wherein  $n$  is an integer,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_{10n}$  of the dopant comprises at least one increased binding energy hydrogen species.
122. A doped semiconductor according to claim 41, wherein said dopant having a formula  $M_qSi_nH_mO_p$  wherein  $q$ ,  $n$ ,  $m$ , and  $p$  are integers,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
123. A doped semiconductor according to claim 41, wherein said dopant having a formula  $M_qSi_nH_m$  wherein  $q$ ,  $n$ , and  $m$  are integers,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
124. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_mO_p$  wherein  $n$ ,  $m$ , and  $p$  are integers, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
125. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_nH_m$  wherein  $n$  and  $m$  are integers, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
126. A doped semiconductor according to claim 41, wherein said dopant having a formula  $MSiH_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
127. A doped semiconductor according to claim 41, wherein said dopant having a formula  $Si_2H_n$  wherein  $n$  is an integer from 1 to 8, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
128. A doped semiconductor according to claim 41, wherein said dopant having a formula  $SiH_n$  wherein  $n$  is an integer from 1 to 8, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.

129. A doped semiconductor according to claim 41, wherein said dopant having a formula  $\text{SiO}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 6, and the hydrogen content  $\text{H}_n$  of the dopant comprises at least one increased binding energy hydrogen species.
130. A doped semiconductor according to claim 41, wherein said dopant having a formula  $\text{MSiO}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $\text{H}_n$  of the dopant comprises at least one increased binding energy hydrogen species.
131. A doped semiconductor according to claim 41, wherein said dopant having a formula  $\text{MSi}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 14,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $\text{H}_n$  of the dopant comprises at least one increased binding energy hydrogen species.
132. A doped semiconductor according to claim 41, wherein said dopant having a formula  $\text{M}_2\text{SiH}_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $\text{H}_n$  of the dopant comprises at least one increased binding energy hydrogen species.
133. A method of making a doped semiconductor comprising;  
     providing a semiconductor material; and  
     doping said semiconductor material with an increased binding energy hydrogen species to form said doped semiconductor.
134. A method according to claim 133, wherein said semiconductor has an altered band gap relative to the semiconductor material which is undoped.
135. A method according to claim 133, wherein said semiconductor has an altered band gap relative to the semiconductor material which is doped with a dopant other than said increased binding energy hydrogen compound.
136. A method according to claim 133, wherein the semiconductor material comprises at least one selected from the group consisting of silicon, boron, aluminum, Group III elements, Group IV elements and Group V elements.
137. A method according to claim 133, wherein said semiconductor material is doped using ion implantation.
138. A method according to claim 133, wherein said semiconductor material is doped using epitaxy.
139. A method according to claim 133, wherein said semiconductor material is doped using vacuum deposition.

140. A method according to claim 133, wherein said increased binding hydrogen species comprises a hydrido atom having a desired energy level.
141. A method according to claim 133, wherein said increased binding energy hydrogen species comprises at least one neutral, positive or negative increased binding energy hydrogen species having a binding energy:
  - (i) greater than the binding energy of the corresponding ordinary hydrogen species, or
  - (ii) greater than the binding energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energy of the ordinary hydrogen species at ambient conditions, or is negative.
142. A method according to claim 141, wherein said increased binding energy hydrogen species is selected from the group consisting of  $H_n$ ,  $H_n^-$ , and  $H_n^+$ , where  $n$  is an integer of 1 to 8, and  $n$  is greater than 1 when  $H$  has a positive charge.
143. A method according to claim 141, wherein said increased binding energy hydrogen species comprises at least one selected from the group consisting of a proton, ordinary hydride ion, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions and ordinary  $H_3^+$ .
144. A method according to claim 141, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.
145. A method according to claim 141, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of organic compounds.
146. A method according to claim 141, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of semiconductors.
147. A method according to claim 133, wherein said increased binding hydrogen species is selected from the group consisting of (a) a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for  $p = 2$  up to 23 in which the binding energy is represented by



$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and e is the elementary charge; (b) hydrogen atom having a binding energy greater than about 13.6 eV; (c) hydrogen molecule having a first binding energy greater than about 15.5 eV; and (d) molecular hydrogen ion having a binding energy greater than about 16.4 eV.

148. A method according to claim 133, wherein the increased binding energy species is hydride ion having a binding energy of about 3.0, 6.6, 11.2, 16.7, 22.8 29.3, 36.1, 42.8, 49.4, 55.5, 61.0, 65.6, 69.2, 71.53, 72.4, 71.54, 68.8, 64.0, 56.8, 47.1, 34.6, or 19.2.
149. A method according to claim 133, wherein said increased binding energy hydrogen species is a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for  $p = 2$  up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and e is the elementary charge.

150. A method according to claim 133, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydrino atom having a binding energy of about  $13.6 \text{ eV}/(1/p)^2$ , where p is an integer greater than 1; (b) a hydride ion having a binding energy represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left( 1 + \frac{2^2}{\left[ \frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where  $p$  is an integer greater than 1,  $s = \frac{1}{2}$ ,  $\hbar$  is Plank's constant bar,  $\mu_0$  is the permeability of vacuum,  $m_e$  is the mass of the electron,  $\mu_e$  is the reduced electron mass,  $a_0$  is the Bohr radius, and  $e$  is the elementary charge; (c) a trihydrino molecular ion,  $H_3^+$  ( $1/p$ ), having a binding energy of about  $22.6/(1/p)^2$  eV; (d) an increased binding energy hydrogen molecule having a binding energy of about  $15.5/(1/p)^2$  eV; and (e) an increased binding energy hydrogen molecular ion with a binding energy of about  $16.4/(1/p)^2$  eV.

151. A method according to claim 150, wherein  $p$  is 2 to 200.
152. A method according to claim 133, wherein said increased binding energy hydrogen species has a negative charge.
153. A method according to claim 133, wherein said increased binding energy hydrogen species further comprises at least one cation.
154. A method according to claim 153, wherein said cation is a proton,  $H_2^+$  or  $H_3^+$ .
155. A method according to claim 133, wherein said at least one increased binding energy hydrogen species having an observed characteristic different from that of the corresponding ordinary compound wherein the hydrogen content is only ordinary hydrogen, said observed characteristic being dependent on the increased binding energy hydrogen species.
156. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydride ion having a binding energy greater than 0.8 eV.
157. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen atom having a binding energy of about  $13.6/n^2$  eV, wherein  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.
158. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen molecule having a first binding energy of about  $15.5/n^2$  eV, wherein  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.

159. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one increased binding energy molecular hydrogen ion having a first binding energy of about  $16.4/n^2$  eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
160. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one hydride ion having a binding energy of about 0.65 eV.
161. A method according to claim 133, wherein said increased binding energy hydrogen species comprising at least one hydride ion formulated from at least one hydrino atom.
162. A method according to claim 133, wherein said increased binding energy hydrogen species comprising  $H_3^+$  increased binding energy hydrogen species.
163. A method according to claim 133, wherein said increased binding energy hydrogen species further comprises at least one other element.
164. A method according to claim 163, wherein said at least one other element comprises at least one selected from the group consisting of ions and compounds containing an increased binding energy species.
165. A method according to claim 163, wherein said at least one other element comprises one or more normal hydrogen atoms.
166. A method according to claim 163, wherein said at least one other element comprises at least one selected from the group consisting of a proton, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions, ordinary hydride ions, and ordinary  $H_3^+$ .
167. A method according to claim 163, wherein said at least one other element comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.
168. A method according to claim 163, wherein said at least one other element comprises at least one element selected from the group consisting of organic compounds.
169. A method according to claim 163, wherein said at least one other element comprises at least one element selected from the group consisting of semiconductors.
170. A method according to claim 163, wherein said at least one other element

comprises a refractory metal.

171. A doped semiconductor according to claim 163, wherein said at least one other element comprises a metal.
172. A doped semiconductor according to claim 163, wherein said at least one other element comprises an electrical conductor.
173. A doped semiconductor according to claim 163, wherein said at least one other element comprises a source of thermal electrons.
174. A method according to claim 163, wherein said semiconductor is doped with a dopant comprising said increased binding energy hydrogen species.
175. A method according to claim 174, wherein the dopant has the formula selected from the group of formulae consisting of  $MH$ ,  $MH_2$ , and  $M_2H_2$  wherein  $M$  is an alkali cation and  $H$  is selected from the group consisting of increased binding energy hydride ions, hydrino atoms and dihydrino molecules.
176. A method according to claim 174, wherein the dopant has the formula  $MH_n$  wherein  $n$  is 1 or 2,  $M$  is an alkaline earth cation and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
177. A method according to claim 174, wherein the dopant has the formula  $MHX$  wherein  $M$  is an alkali cation,  $X$  is one of a neutral atom, a molecule, or a singly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
178. A method according to claim 177, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
179. A method according to claim 174, wherein the dopant has the formula  $MHX$  wherein  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
180. A method according to claim 179, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
181. A method according to claim 174, wherein the dopant has the formula  $MHX$  wherein  $M$  is an alkaline earth cation,  $X$  is a doubly negatively charged anion, and  $H$  is a hydrino atom.

182. A method according to claim 181, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
183. A method according to claim 174, wherein the dopant has the formula  $M_2HX$  wherein M is an alkali cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
184. A method according to claim 183, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
185. A method according to claim 174, wherein the dopant has the formula  $MH_n$  wherein n is an integer from 1 to 5, M is an alkali cation and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
186. A method according to claim 174, wherein the dopant has the formula  $M_2H_n$  wherein n is an integer from 1 to 4, M is an alkaline earth cation and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
187. A method according to claim 174, wherein the dopant has the formula  $M_2XH_n$  wherein n is an integer from 1 to 3, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
188. A method according to claim 187, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
189. A method according to claim 174, wherein the dopant has the formula  $M_2X_2H_n$  wherein n is 1 or 2, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
190. A method according to claim 189, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
191. A method according to claim 174, wherein the dopant has the formula  $M_2X_3H$  wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
192. A method according to claim 191, wherein said singly negatively charged anion

is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

193. A method according to claim 174, wherein the dopant has the formula  $M_2XH_n$  wherein  $n$  is 1 or 2,  $M$  is an alkaline earth cation,  $X$  is a doubly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
194. A method according to claim 193, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
195. A method according to claim 174, wherein the dopant has the formula  $M_2XX'H$  wherein  $M$  is an alkaline earth cation,  $X$  is a singly negatively charged anion,  $X'$  is a doubly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
196. A method according to claim 195, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
197. A method according to claim 195, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
198. A method according to claim 174, wherein the dopant has the formula  $MM'H_n$  wherein  $n$  is an integer from 1 to 3,  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
199. A method according to claim 174, wherein the dopant is  $MM'XH_n$  wherein  $n$  is 1 to 2,  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation,  $X$  is a singly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
200. A method according to claim 199, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
201. A method according to claim 174, wherein the dopant is  $MM'XH$  where  $M$  is an alkaline earth cation,  $M'$  is an alkali metal cation,  $X$  is a doubly negatively charged anion, and  $H$  is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
202. A method according to claim 201, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

203. A method according to claim 174, wherein the dopant has the formula  $MM'XX'H$  where M is an alkaline earth cation, M' is an alkali metal cation, X and X' are each a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
204. A method according to claim 203, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
205. A method according to claim 174, wherein the dopant has the formula  $H_nS$  wherein n is 1 or 2, and the hydrogen content of  $H_n$  comprises at least one increased binding energy hydrogen species.
206. A method according to claim 174, wherein the dopant has the formula  $MSiH_n$  wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content of  $H_n$  comprises at least one increased binding energy hydrogen species.
207. A method according to claim 174, wherein the dopant has the formula  $MXM'H_n$  wherein
  - n is an integer from 1 to 5;
  - M is an alkali or alkaline earth cation;
  - X is a singly negatively charged anion or a doubly negatively charged anion;
  - M' is selected from the group consisting of Si, Al, Ni, the transition elements, the inner transition elements, and the rare earth elements; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
208. A method according to claim 207, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
209. A method according to claim 207, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
210. A method according to claim 174, wherein the dopant has the formula  $MAIH_n$  wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
211. A method according to claim 174, wherein the dopant has the formula  $MH_n$  wherein:
  - n is an integer from 1 to 6;
  - M is selected from the group consisting of the transition elements, the

inner transition elements, and the rare earth element cations and nickel; and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.

212. A method according to claim 174, wherein the dopant has the formula  $MNiH_n$  wherein:
  - $n$  is an integer from 1 to 6;
  - $M$  is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
213. A method according to claim 174, wherein the dopant has the formula  $MM'H_n$  wherein:
  - $n$  is an integer from 1 to 6;
  - $M$  is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum;
  - $M'$  is selected from the group consisting of the transition elements, the inner transition elements, and rare earth element cations; and
  - the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
214. A method according to claim 174, wherein the dopant has the formula  $M_2SiH_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
215. A method according to claim 174, wherein the dopant has the formula  $Si_2H_n$  wherein  $n$  is an integer from 1 to 8, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
216. A method according to claim 174, wherein the dopant has the formula  $SiH_n$  wherein  $n$  is an integer from 1 to 8, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
217. A method according to claim 174, wherein the dopant has the formula  $TiH_n$  wherein  $n$  is an integer from 1 to 4, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
218. A method according to claim 174, wherein the dopant has the formula  $Al_2H_n$  wherein  $n$  is an integer from 1 to 4 and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
219. A method according to claim 174, wherein the dopant has the formula  $MXAlX'H_n$  wherein  $n$  is 1 or 2,  $M$  is an alkali or alkaline earth cation,  $X$  and  $X'$  are each



either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.

220. A method according to claim 219, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
221. A method according to claim 219, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
222. A method according to claim 174, wherein the dopant has the formula  $MXSiX'H_n$  wherein  $n$  is 1 or 2,  $M$  is an alkali or alkaline earth cation,  $X$  and  $X'$  are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
223. A method according to claim 222, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
224. A method according to claim 222, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
225. A method according to claim 174, wherein the dopant has the formula  $SiO_2H_n$  wherein  $n$  is an integer from 1 to 6 and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
226. A method according to claim 174, wherein the dopant has the formula  $MSiO_2H_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
227. A method according to claim 174, wherein the dopant has the formula  $MSi_2H_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
228. A method according to claim 174, wherein the dopant has the formula  $M_2SiH_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  comprises at least one increased binding energy hydrogen species.
229. A method according to claim 174, wherein said dopant having a formula  $[KH_mKCO_3]_n$  wherein  $m$  and  $n$  are each an integer and the hydrogen content  $H_m$

of the dopant comprises at least one increased binding energy hydrogen species.

230. A method according to claim 174, wherein said dopant having a formula  $[KH_mKNO_3]_n^+ nX^-$  wherein m and n are each an integer, X is a singly negatively charged anion, and the hydrogen content of  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
231. A method according to claim 230, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
232. A method according to claim 174, wherein said dopant having a formula  $[KHKNO_3]_n$  wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
233. A method according to claim 174, wherein said dopant having a formula  $[KHKOH]_n$  wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
234. A method according to claim 174, wherein said dopant having a formula  $[MH_mM'X]_n$  wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negatively charged anion, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
235. A method according to claim 234, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
236. A method according to claim 234, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
237. A method according to claim 174, wherein said dopant having a formula  $[MH_mM'X]_n^+ nX^-$  wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X and X' are a singly or doubly negatively charged anion, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
238. A method according to claim 237, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
239. A method according to claim 237, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.

240. A method according to claim 174, wherein said dopant having a formula  $\text{MXSiX}'\text{H}_n$  wherein  $n$  is 1 or 2,  $M$  is an alkali or alkaline earth cation,  $X$  and  $X'$  are with a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
241. A method according to claim 240, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
242. A method according to claim 240, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
243. A method according to claim 174, wherein said dopant having a formula  $\text{MSiH}_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
244. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_n\text{H}_{4n}$  wherein  $n$  is an integer and the hydrogen content  $H_{4n}$  of the dopant comprises at least one increased binding energy hydrogen species.
245. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_n\text{H}_{3n}$  wherein  $n$  is an integer and the hydrogen content  $H_{3n}$  of the dopant comprises at least one increased binding energy hydrogen species.
246. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_n\text{H}_{3n}\text{O}_m$  wherein  $n$  and  $m$  are integers and the hydrogen content  $H_{3n}$  of the dopant comprises at least one increased binding energy hydrogen species.
247. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_x\text{H}_{4x-2y}\text{O}_y$  wherein  $x$  and  $y$  are each an integer and the hydrogen content  $H_{4x-2y}$  of the dopant comprises at least one increased binding energy hydrogen species.
248. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_x\text{H}_{4x}\text{O}_y$  wherein  $x$  and  $y$  are each an integer and the hydrogen content  $H_{4x}$  of the dopant comprises at least one increased binding energy hydrogen species.
249. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_n\text{H}_{4n}\text{H}_2\text{O}$  wherein  $n$  is an integer and the hydrogen content  $H_{4n}$  of the dopant comprises at least one increased binding energy hydrogen species.
250. A method according to claim 174, wherein said dopant having a formula  $\text{Si}_n\text{H}_{2n+2}$  wherein  $n$  is an integer and the hydrogen content  $H_{2n+2}$  of the dopant comprises

at least one increased binding energy hydrogen species.

251. A method according to claim 174, wherein said dopant having a formula  $Si_xH_{2x+2}O_y$  wherein x and y are each an integer and the hydrogen content  $H_{2x+2}$  of the dopant comprises at least one increased binding energy hydrogen species.
252. A method according to claim 174, wherein said dopant having a formula  $Si_nH_{4n-2}O$  wherein n is an integer and the hydrogen content  $H_{4n-2}$  of the dopant comprises at least one increased binding energy hydrogen species.
253. A method according to claim 174, wherein said dopant having a formula  $MSi_{4n}H_{10n}O_n$  wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content  $H_{10n}$  of the dopant comprises at least one increased binding energy hydrogen species.
254. A method according to claim 174, wherein said dopant having a formula  $MSi_{4n}H_{10n}O_{n+1}$  wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content  $H_{10n}$  of the dopant comprises at least one increased binding energy hydrogen species.
255. A method according to claim 174, wherein said dopant having a formula  $M_qSi_nH_mO_p$  wherein q, n, m, and p are integers, M is an alkali or alkaline earth cation, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
256. A method according to claim 174, wherein said dopant having a formula  $M_qSi_nH_m$  wherein q, n, and m are integers, M is an alkali or alkaline earth cation, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
257. A method according to claim 174, wherein said dopant having a formula  $Si_nH_mO_p$  wherein n, m, and p are integers, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
258. A method according to claim 174, wherein said dopant having a formula  $Si_nH_m$  wherein n and m are integers, and the hydrogen content  $H_m$  of the dopant comprises at least one increased binding energy hydrogen species.
259. A method according to claim 174, wherein said dopant having a formula  $MSiH_n$  wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
260. A method according to claim 174, wherein said dopant having a formula  $Si_2H_n$  wherein n is an integer from 1 to 8, and the hydrogen content  $H_n$  of the dopant

comprises at least one increased binding energy hydrogen species.

261. A method according to claim 174, wherein said dopant having a formula  $\text{SiH}_n$  wherein  $n$  is an integer from 1 to 8, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
262. A method according to claim 174, wherein said dopant having a formula  $\text{SiO}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 6, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
263. A method according to claim 174, wherein said dopant having a formula  $\text{MSiO}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 6,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
264. A method according to claim 174, wherein said dopant having a formula  $\text{MSi}_2\text{H}_n$  wherein  $n$  is an integer from 1 to 14,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.
265. A method according to claim 174, wherein said dopant having a formula  $\text{M}_2\text{SiH}_n$  wherein  $n$  is an integer from 1 to 8,  $M$  is an alkali or alkaline earth cation, and the hydrogen content  $H_n$  of the dopant comprises at least one increased binding energy hydrogen species.